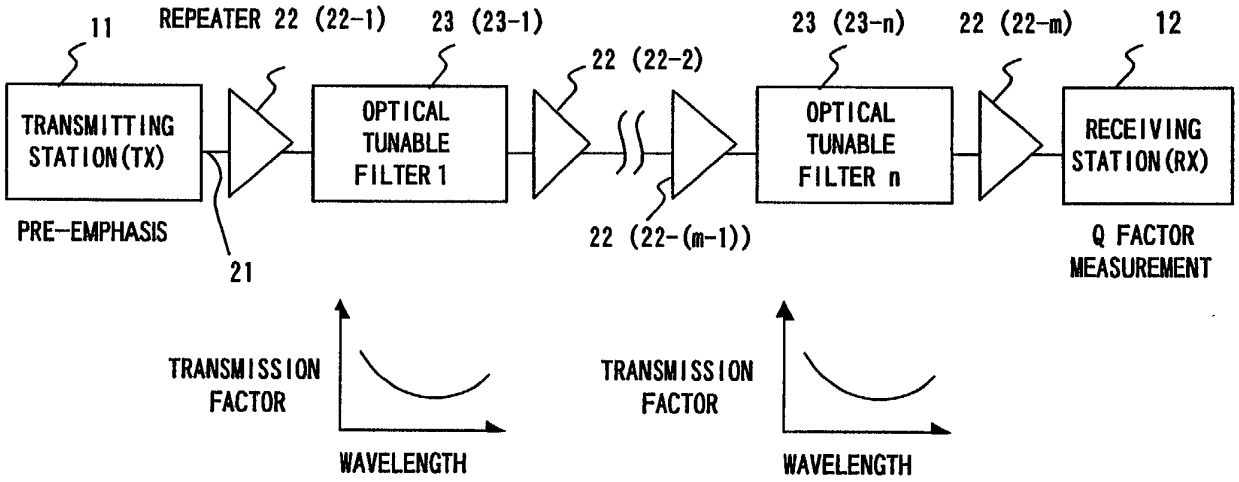
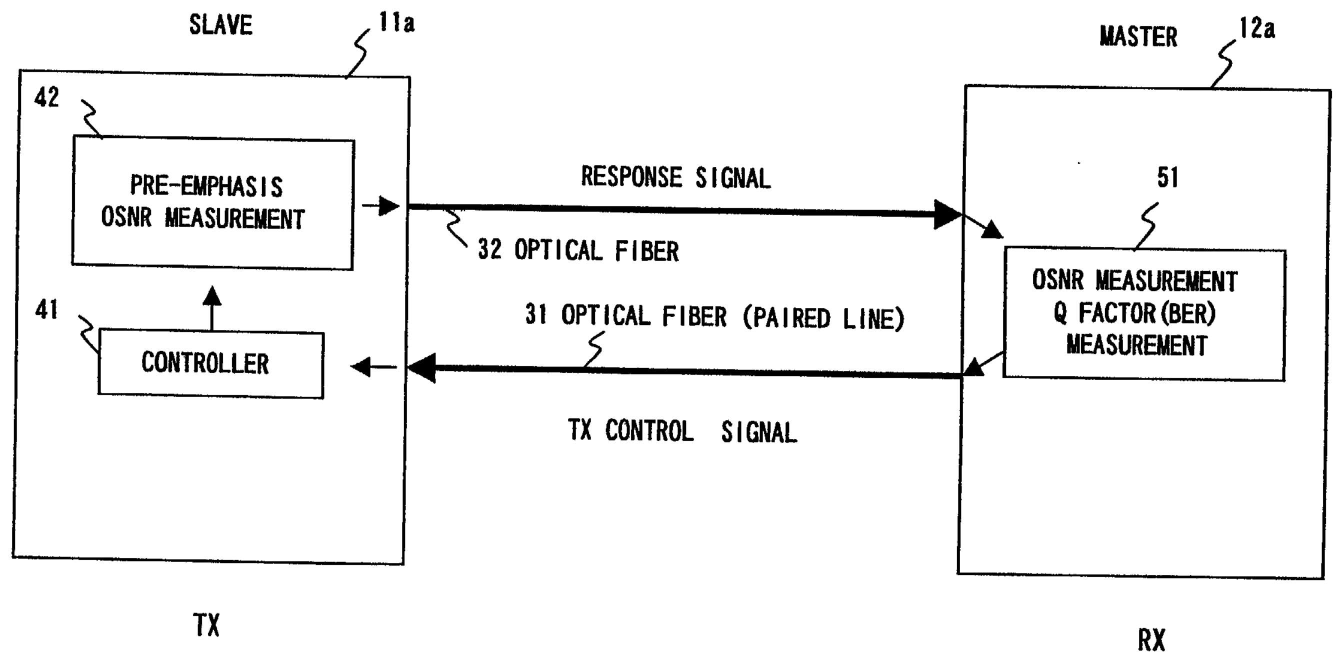


FIG. 1


SLAVE
11a
42
PRE-EMPHASIS
OSNR MEASUREMENT
41
CONTROLLER
TX
RESPONSE SIGNAL
32 OPTICAL FIBER
31 OPTICAL FIBER (PAIRED LINE)
TX CONTROL SIGNAL
MASTER
12a
51
OSNR MEASUREMENT
Q FACTOR (BER)
MEASUREMENT
RX

F I G. 2

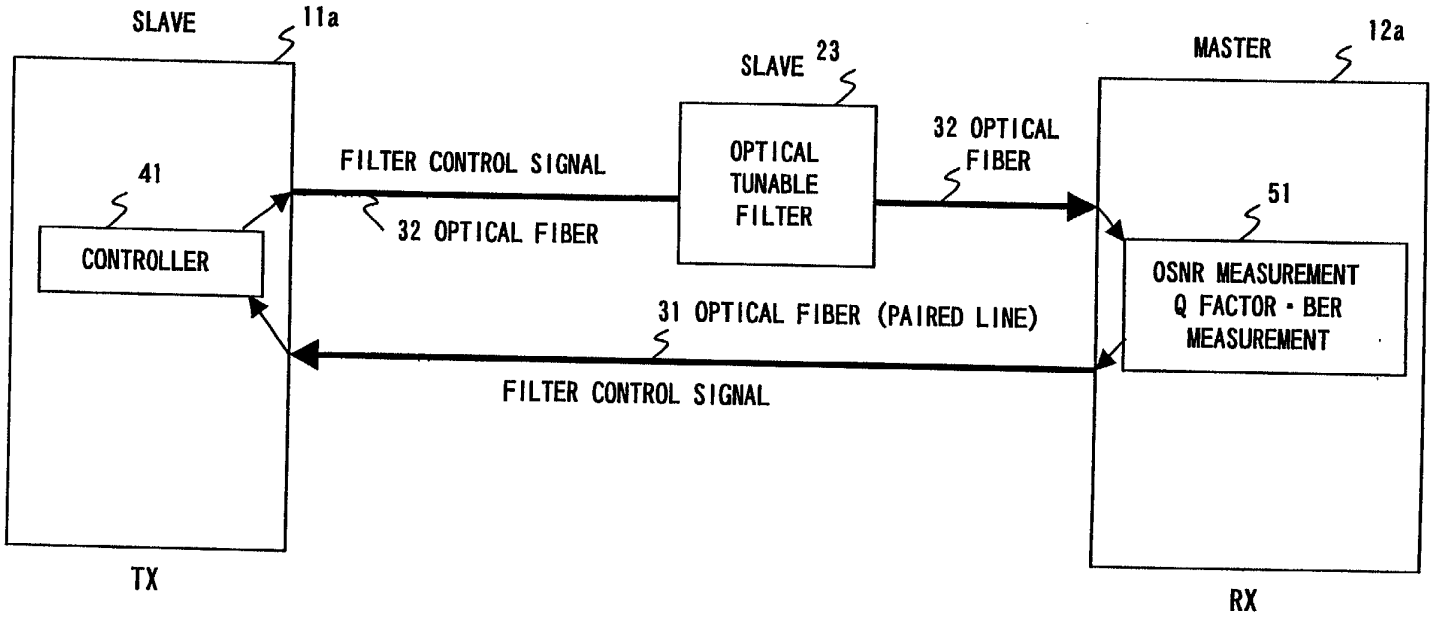

SLAVE
11a
SLAVE 23
MASTER
12a
41
FILTER CONTROL SIGNAL
OPTICAL TUNABLE FILTER
32 OPTICAL FIBER
32 OPTICAL FIBER
51
CONTROLLER
OSNR MEASUREMENT
Q FACTOR · BER
MEASUREMENT
31 OPTICAL FIBER (PAIRED LINE)
FILTER CONTROL SIGNAL
TX
RX

FIG. 3

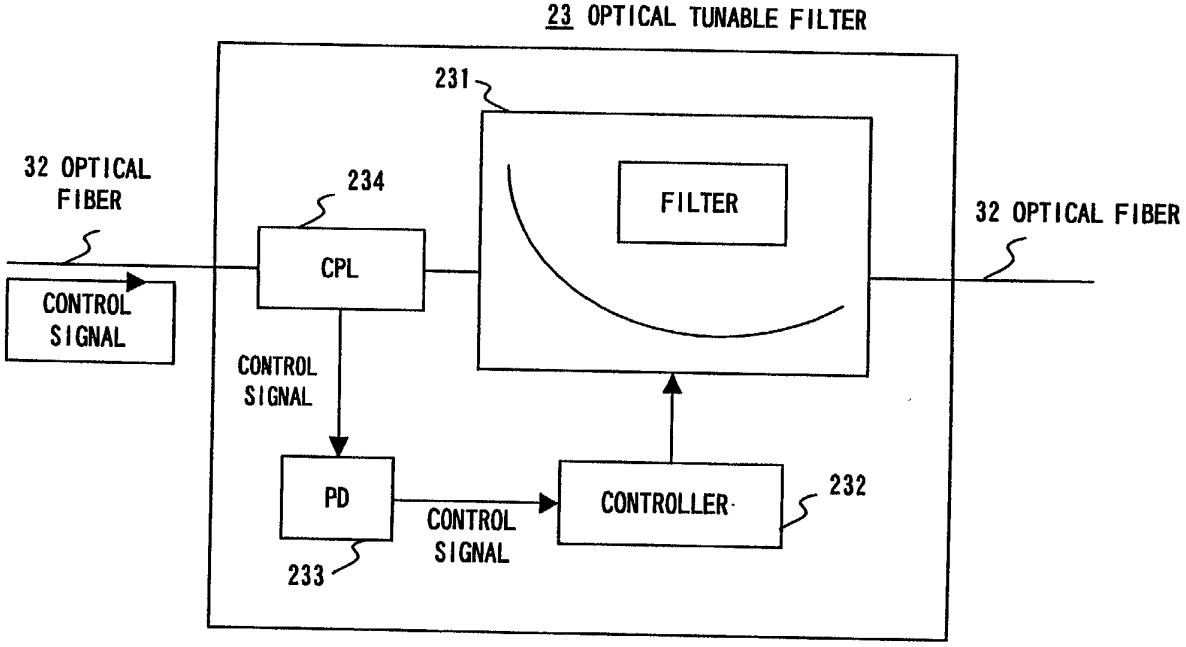
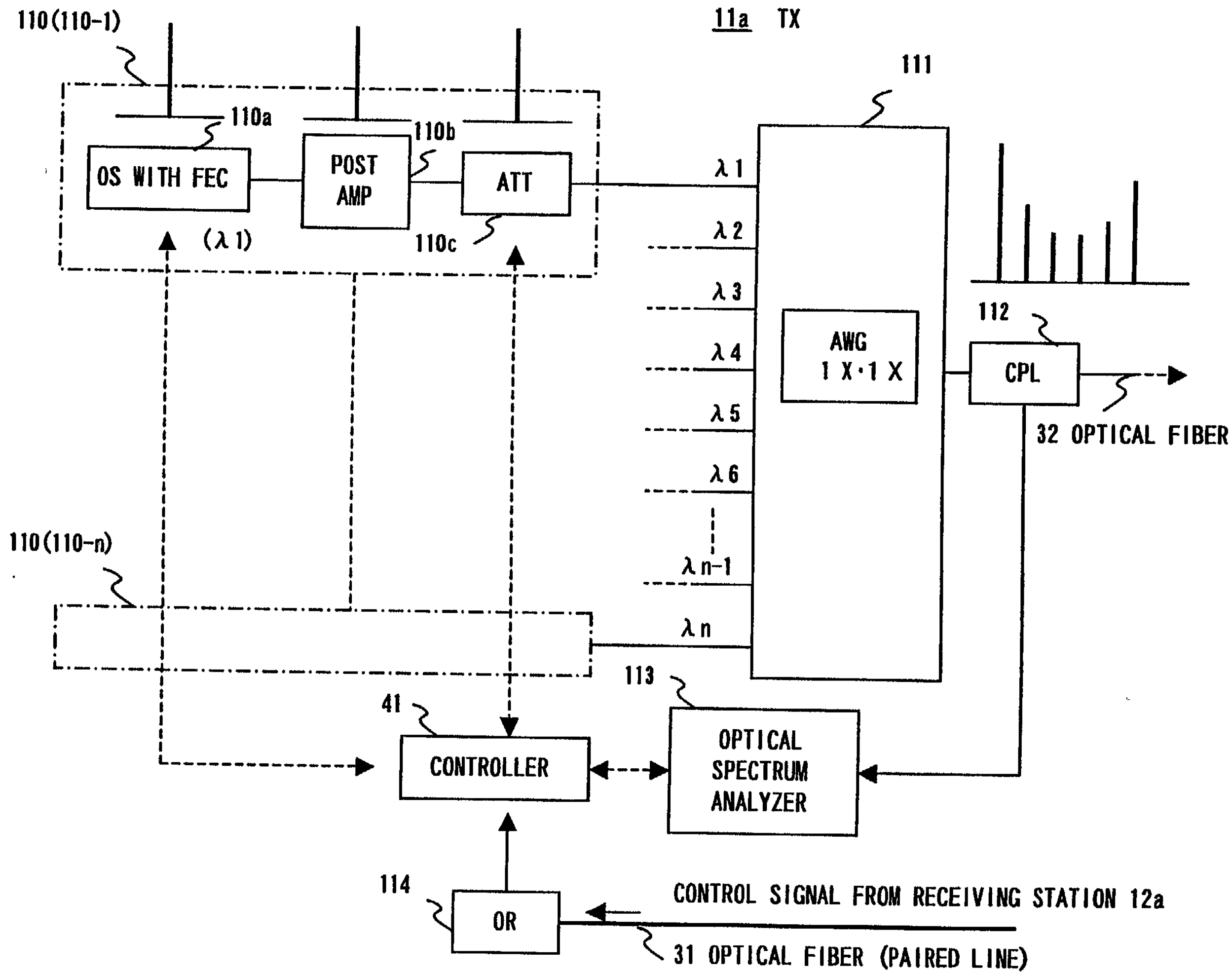


FIG. 4


11a TX
110(110-1)
110a
OS WITH FEC
(λ1)
110b
POST AMP
ATT
110c
111
λ1
λ2
λ3
λ4
λ5
λ6
λn-1
λn
AWG 1 X·1 X
112
CPL
32 OPTICAL FIBER
110(110-n)
113
OPTICAL SPECTRUM ANALYZER
41
CONTROLLER
114
OR
CONTROL SIGNAL FROM RECEIVING STATION 12a
31 OPTICAL FIBER (PAIRED LINE)

F I G. 5

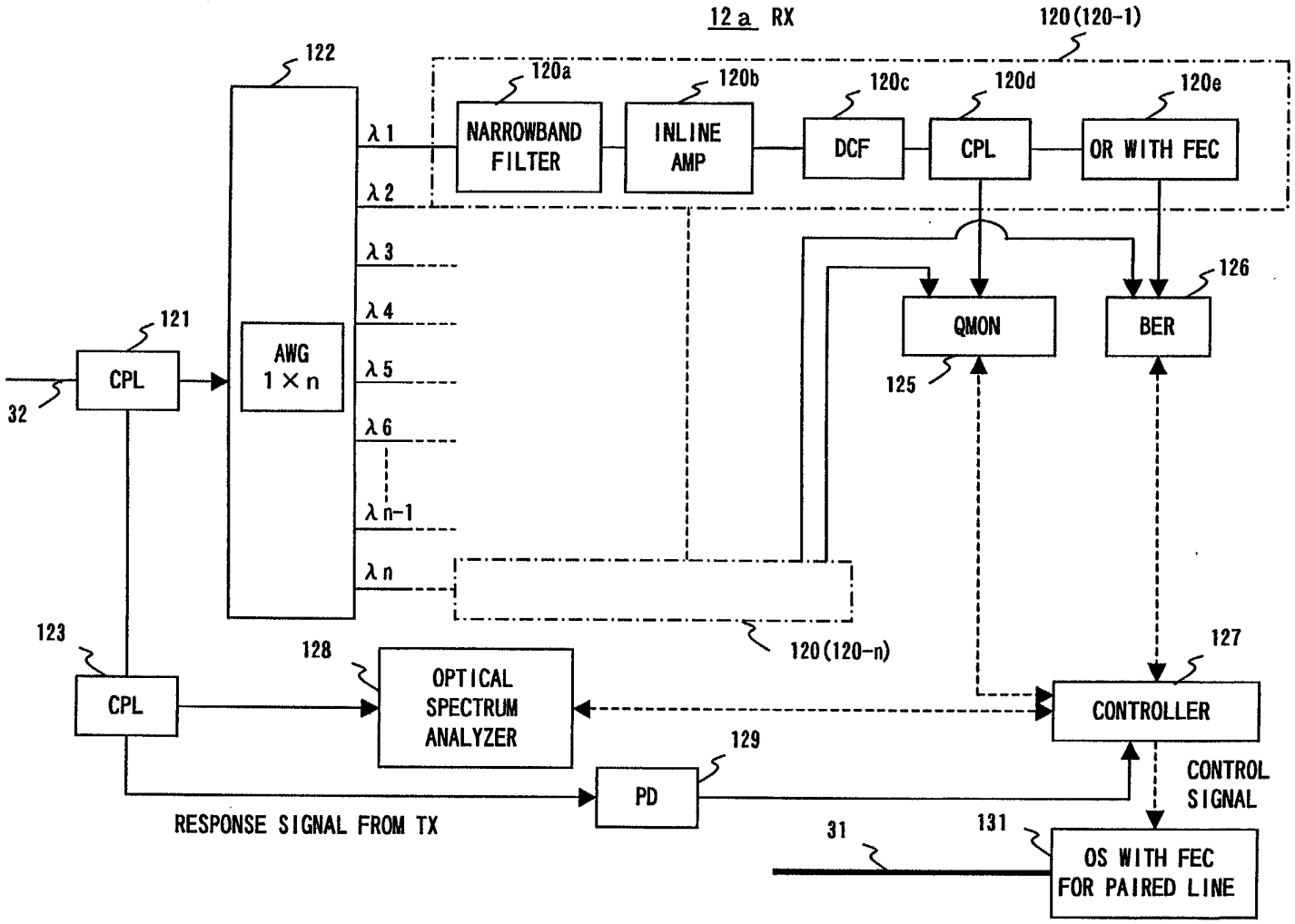

12a RX
120(120-1)
122
120a
120b
120c
120d
120e
λ1
λ2
λ3
λ4
λ5
λ6
λn-1
λn
NARROWBAND FILTER
INLINE AMP
DCF
CPL
OR WITH FEC
121
CPL
32
AWG 1×n
QMON
BER
126
125
120(120-n)
123
128
127
CPL
OPTICAL SPECTRUM ANALYZER
CONTROLLER
129
PD
CONTROL SIGNAL
RESPONSE SIGNAL FROM TX
31
131
OS WITH FEC FOR PAIRED LINE

FIG. 6

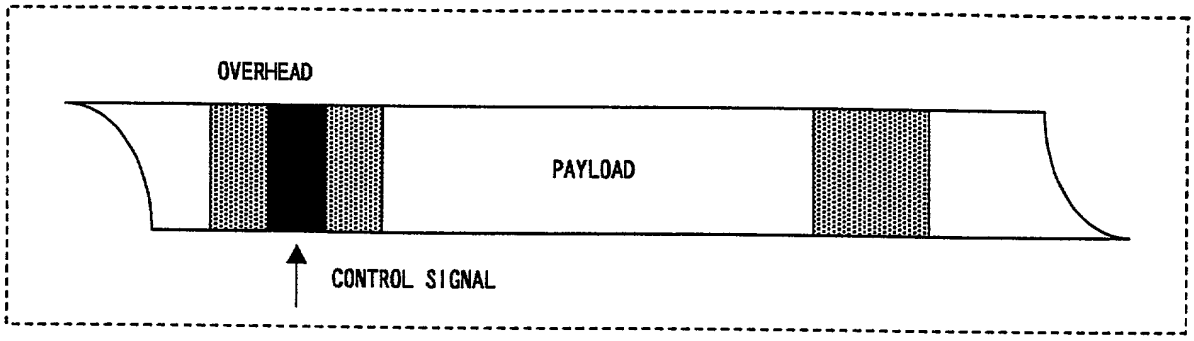


FIG. 7A

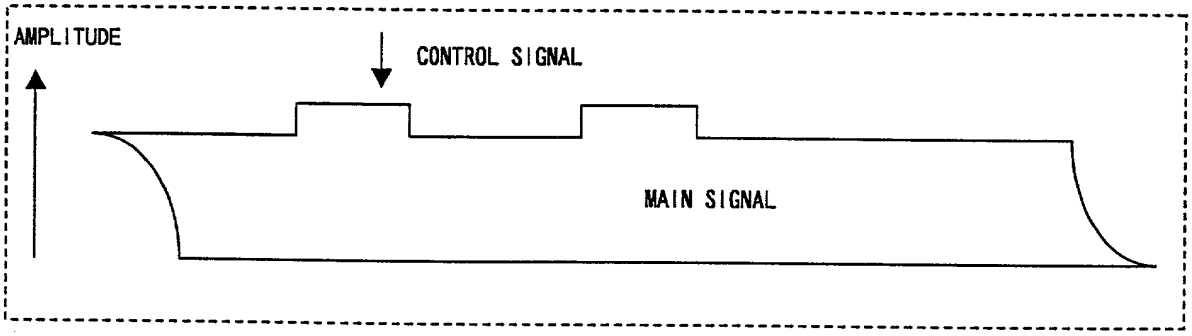


FIG. 7B

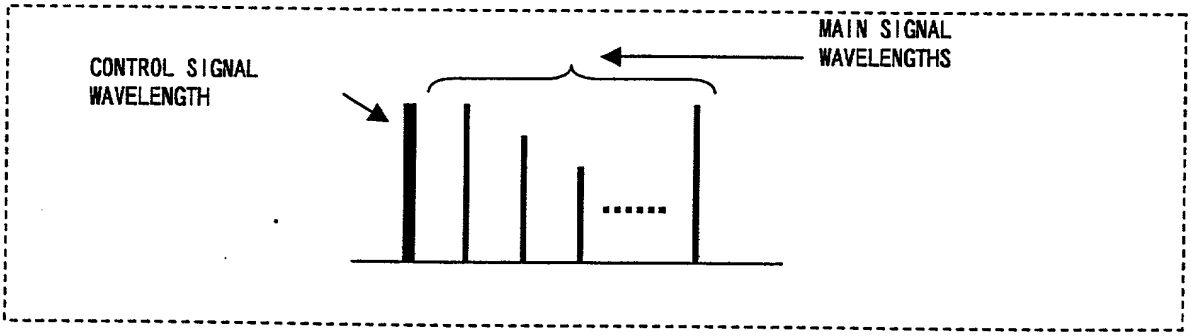


FIG. 7C

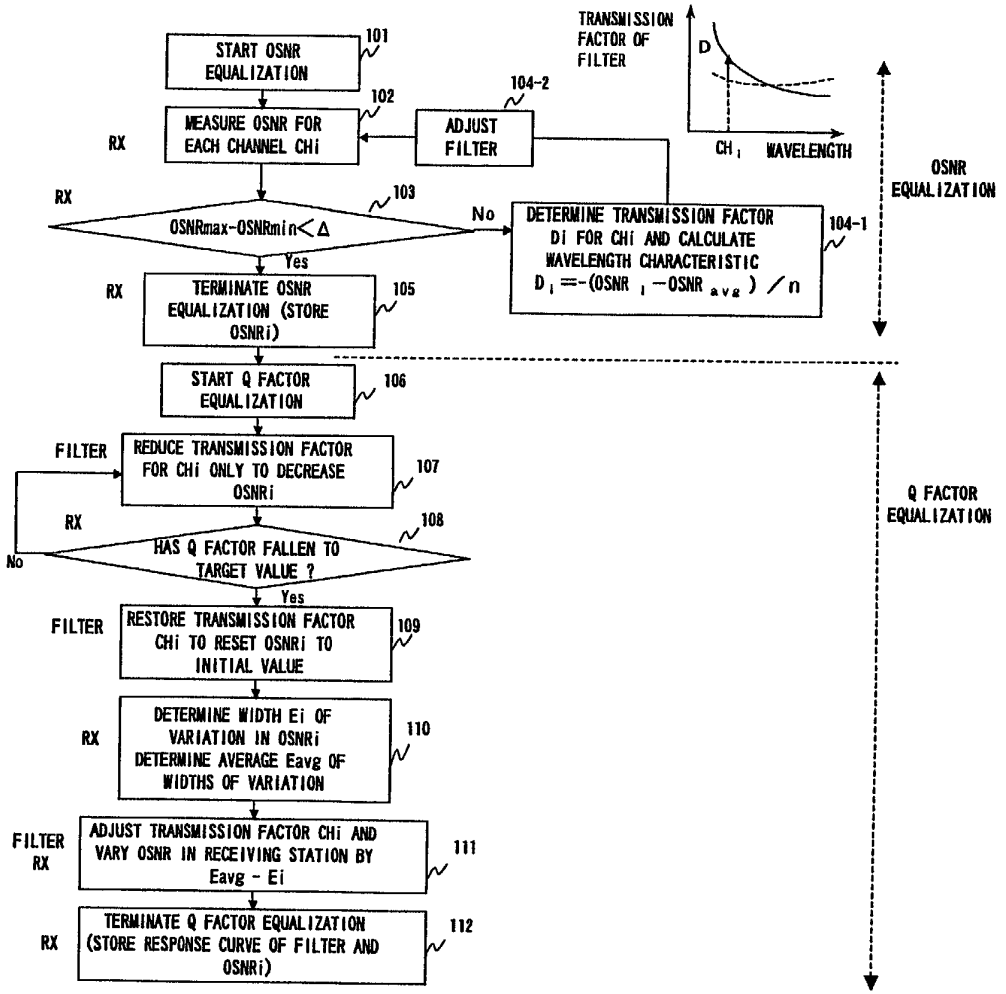


FIG. 8

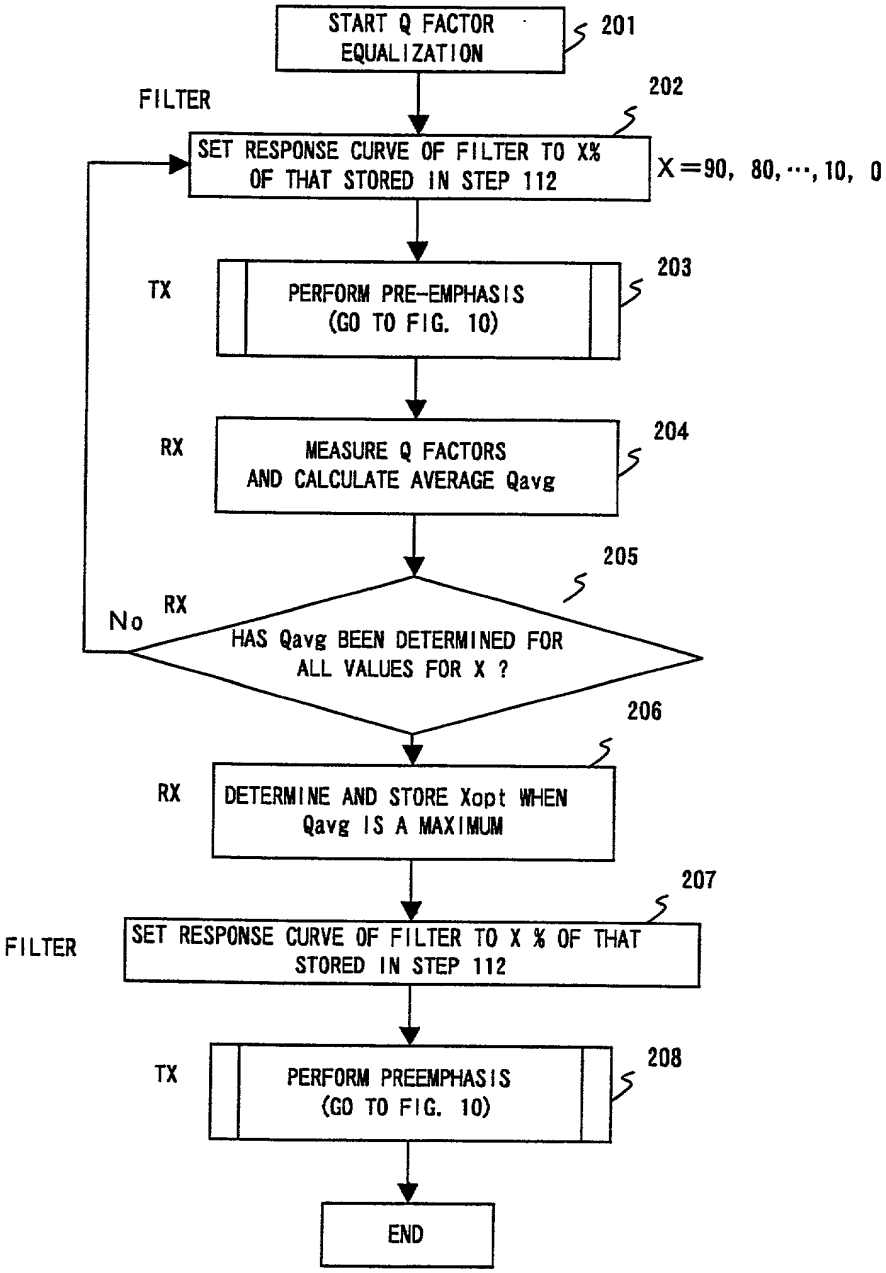
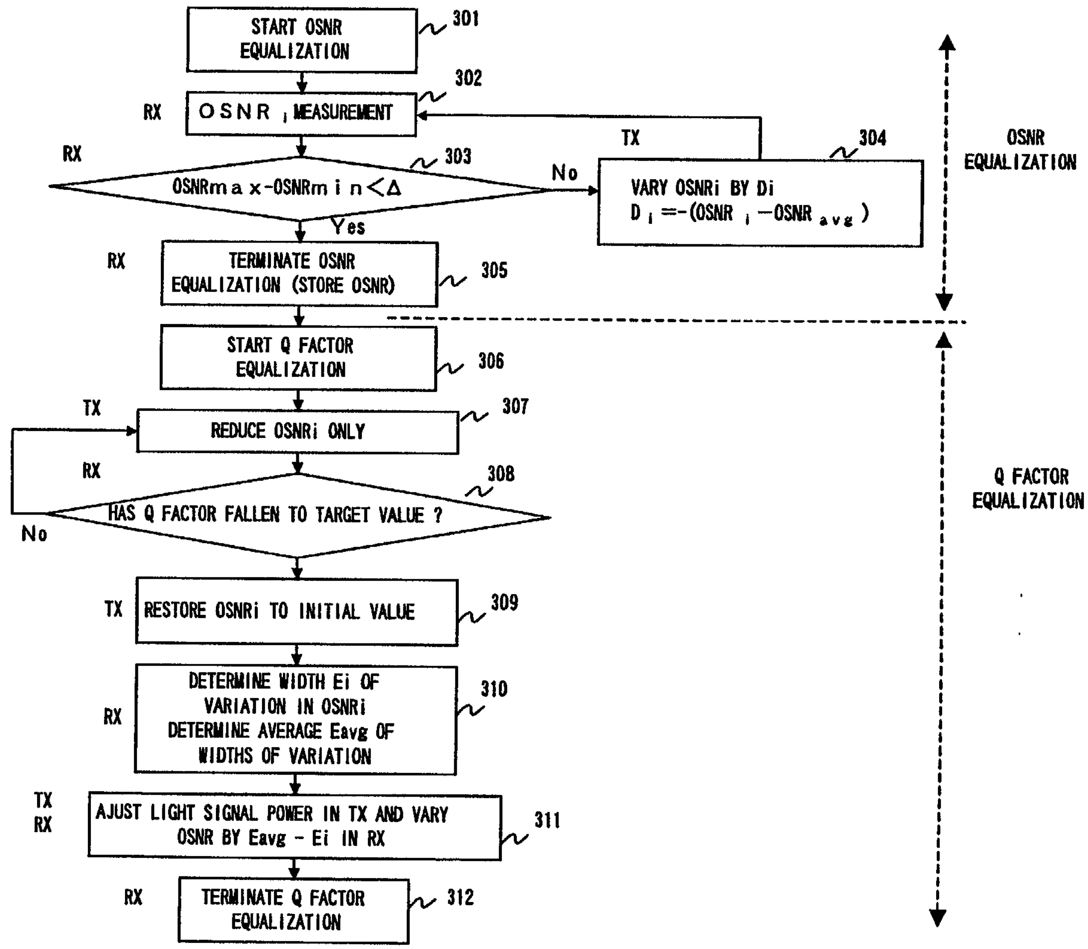

START Q FACTOR EQUALIZATION
201
FILTER
202
SET RESPONSE CURVE OF FILTER TO X% OF THAT STORED IN STEP 112
X=90, 80, ···, 10, 0
TX
PERFORM PRE-EMPHASIS (GO TO FIG. 10)
203
RX
MEASURE Q FACTORS AND CALCULATE AVERAGE Qavg
204
205
No
RX
HAS Qavg BEEN DETERMINED FOR ALL VALUES FOR X ?
206
RX
DETERMINE AND STORE Xopt WHEN Qavg IS A MAXIMUM
207
FILTER
SET RESPONSE CURVE OF FILTER TO X % OF THAT STORED IN STEP 112
TX
PERFORM PREEMPHASIS (GO TO FIG. 10)
208
END

FIG. 9


START OSNR EQUALIZATION
301
RX
OSNR i MEASUREMENT
302
RX
OSNRmax-OSNRmin<Δ
303
No
Yes
TX
VARY OSNRi BY Di
D i =-(OSNR i -OSNR avg)
304
RX
TERMINATE OSNR EQUALIZATION (STORE OSNR)
305
START Q FACTOR EQUALIZATION
306
TX
REDUCE OSNRi ONLY
307
RX
HAS Q FACTOR FALLEN TO TARGET VALUE ?
308
No
TX
RESTORE OSNRi TO INITIAL VALUE
309
RX
DETERMINE WIDTH Ei OF VARIATION IN OSNRi
DETERMINE AVERAGE Eavg OF WIDTHS OF VARIATION
310
TX
RX
AJUST LIGHT SIGNAL POWER IN TX AND VARY OSNR BY Eavg - Ei IN RX
311
RX
TERMINATE Q FACTOR EQUALIZATION
312
OSNR EQUALIZATION
Q FACTOR EQUALIZATION

F I G. 1 0

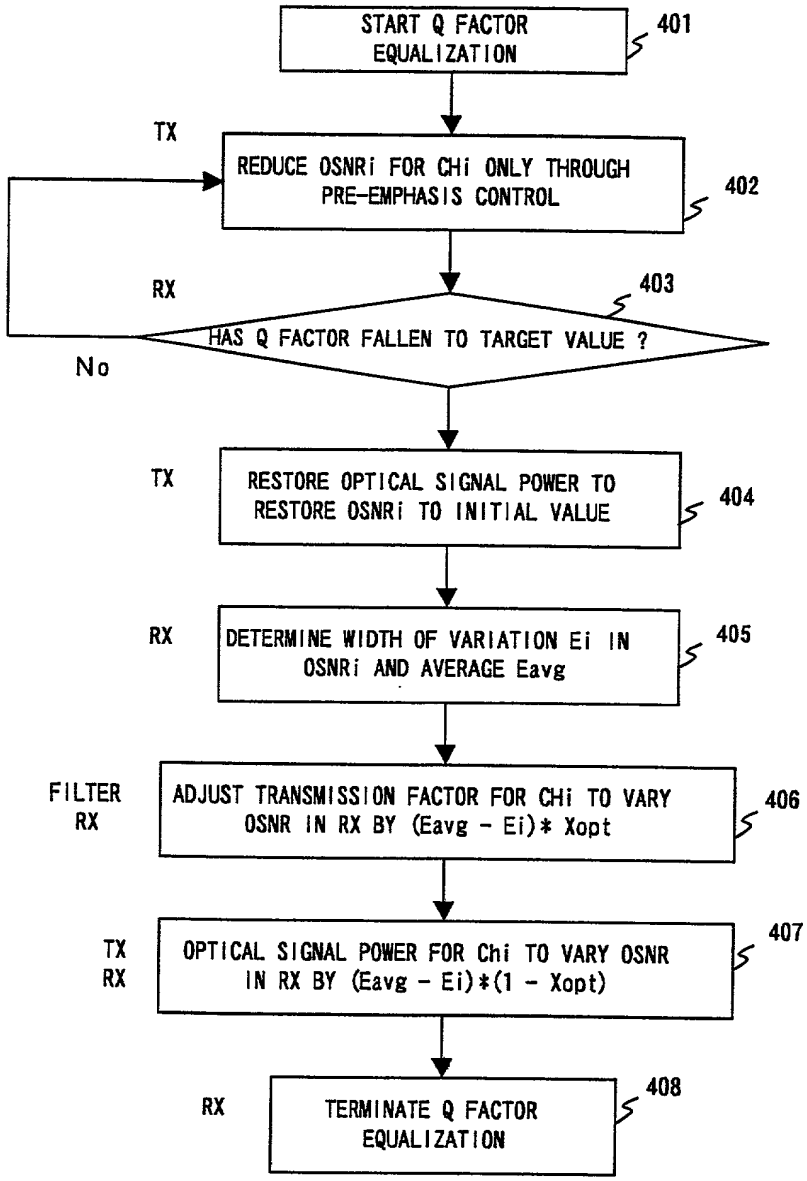
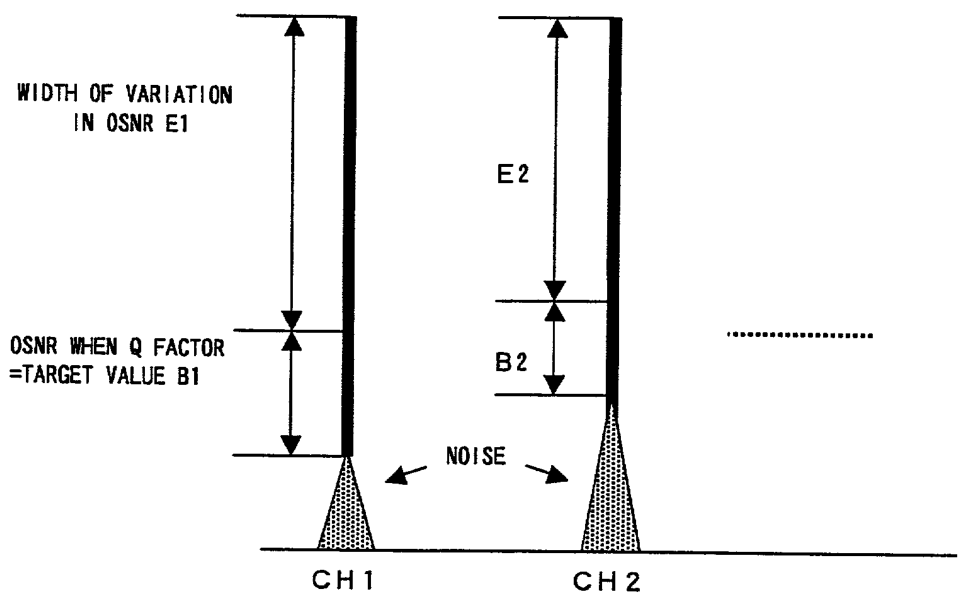

START Q FACTOR EQUALIZATION
401
TX
REDUCE OSNRi FOR CHi ONLY THROUGH PRE-EMPHASIS CONTROL
402
RX
403
HAS Q FACTOR FALLEN TO TARGET VALUE ?
No
TX
RESTORE OPTICAL SIGNAL POWER TO RESTORE OSNRi TO INITIAL VALUE
404
RX
DETERMINE WIDTH OF VARIATION Ei IN OSNRi AND AVERAGE Eavg
405
FILTER RX
ADJUST TRANSMISSION FACTOR FOR CHi TO VARY OSNR IN RX BY (Eavg - Ei)* Xopt
406
TX RX
OPTICAL SIGNAL POWER FOR Chi TO VARY OSNR IN RX BY (Eavg - Ei)*(1 - Xopt)
407
RX
TERMINATE Q FACTOR EQUALIZATION
408

FIG. 11


WIDTH OF VARIATION
IN OSNR E1
OSNR WHEN Q FACTOR
=TARGET VALUE B1
E2
B2
NOISE
CH1
CH2

F I G. 1 2

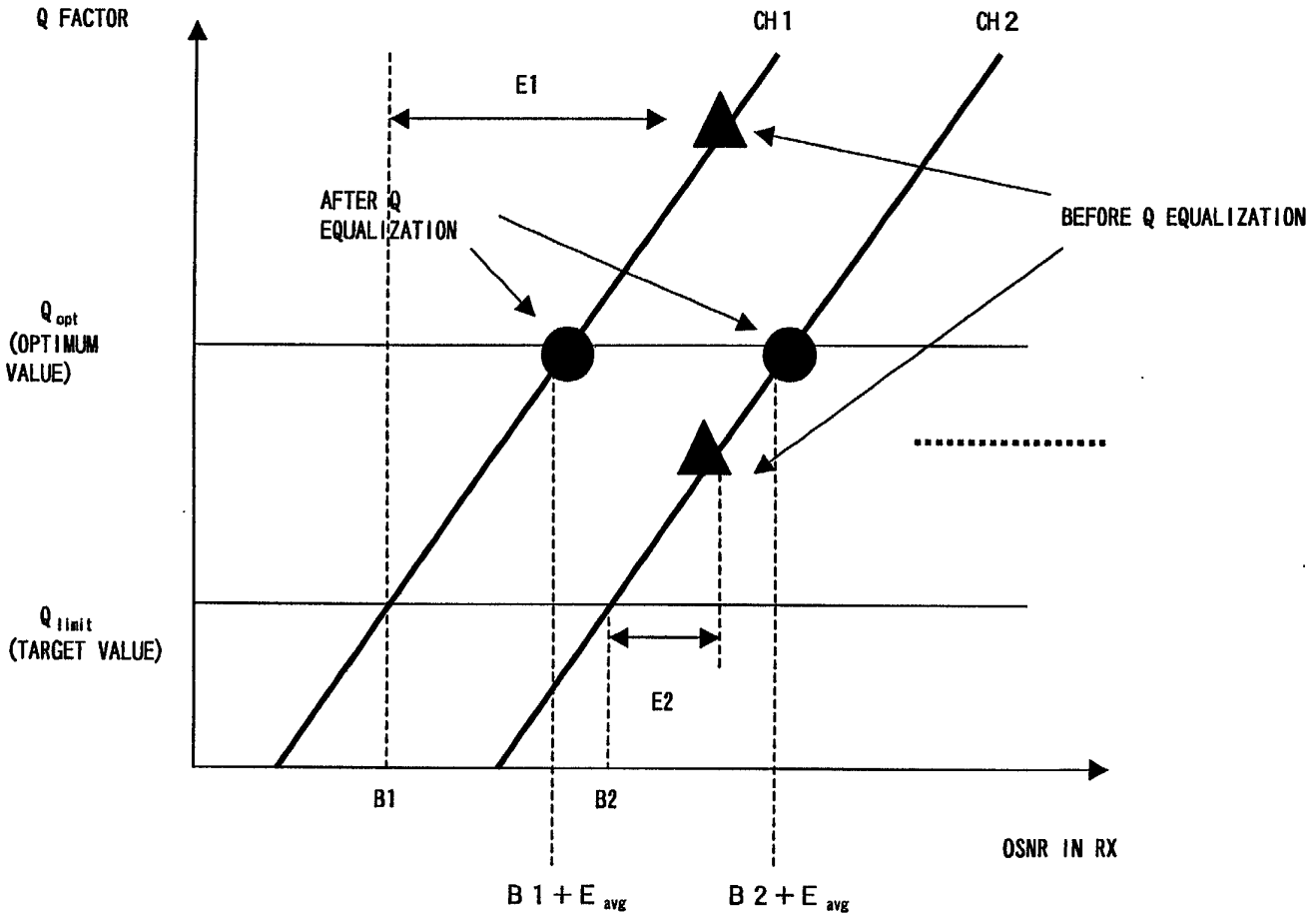

Q FACTOR
CH1
CH2
E1
AFTER Q EQUALIZATION
BEFORE Q EQUALIZATION
Q opt (OPTIMUM VALUE)
Q limit (TARGET VALUE)
E2
B1
B2
OSNR IN RX
B1+E avg
B2+E avg

FIG. 13

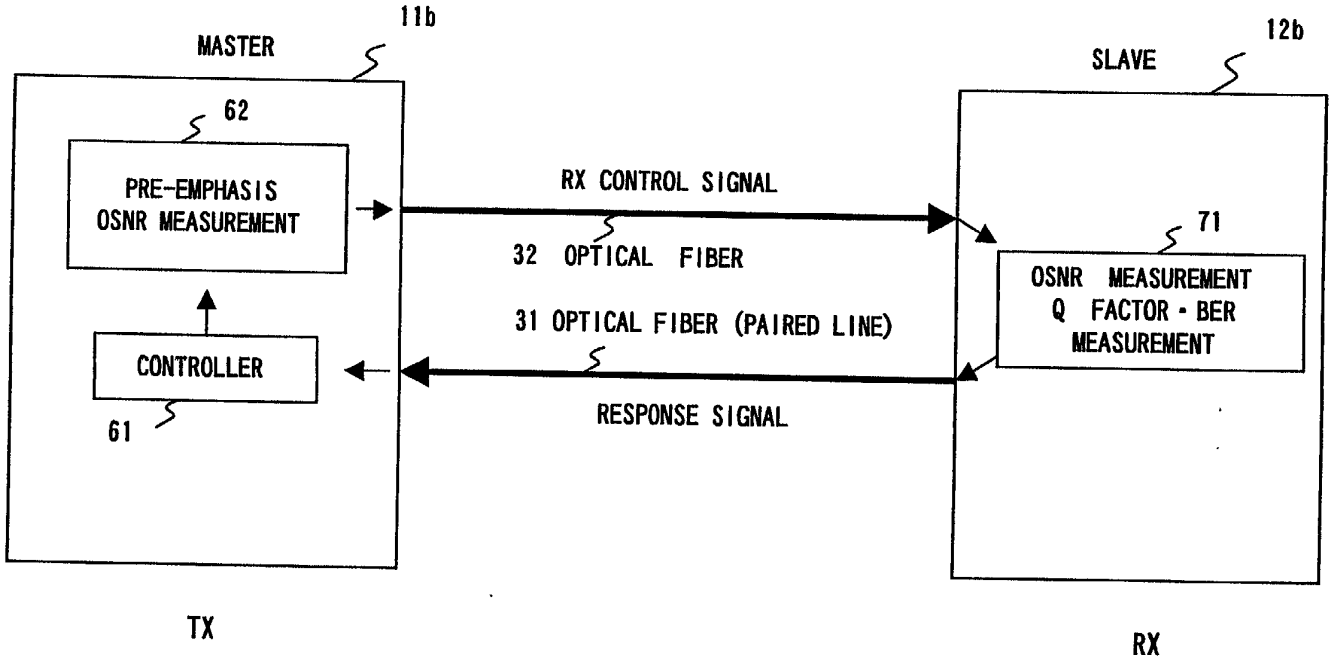


FIG. 14

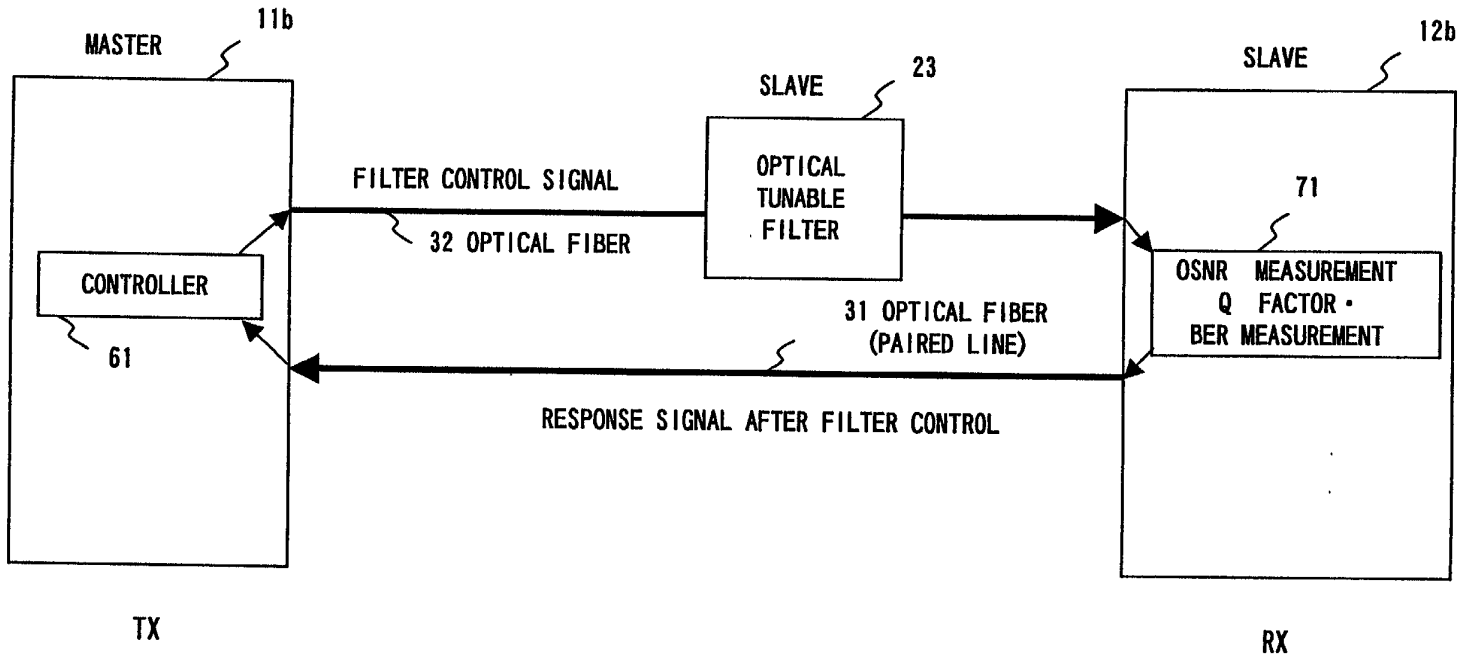


FIG. 15

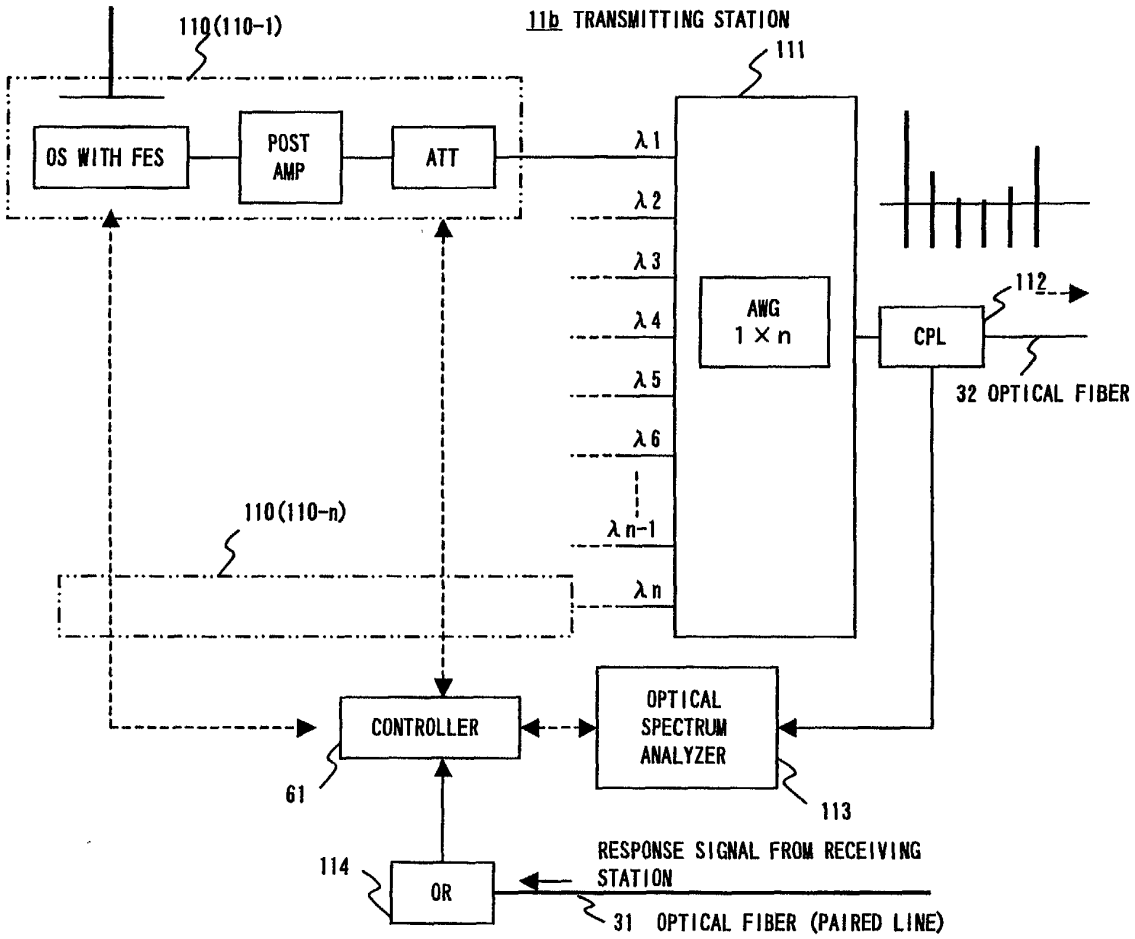


FIG. 16

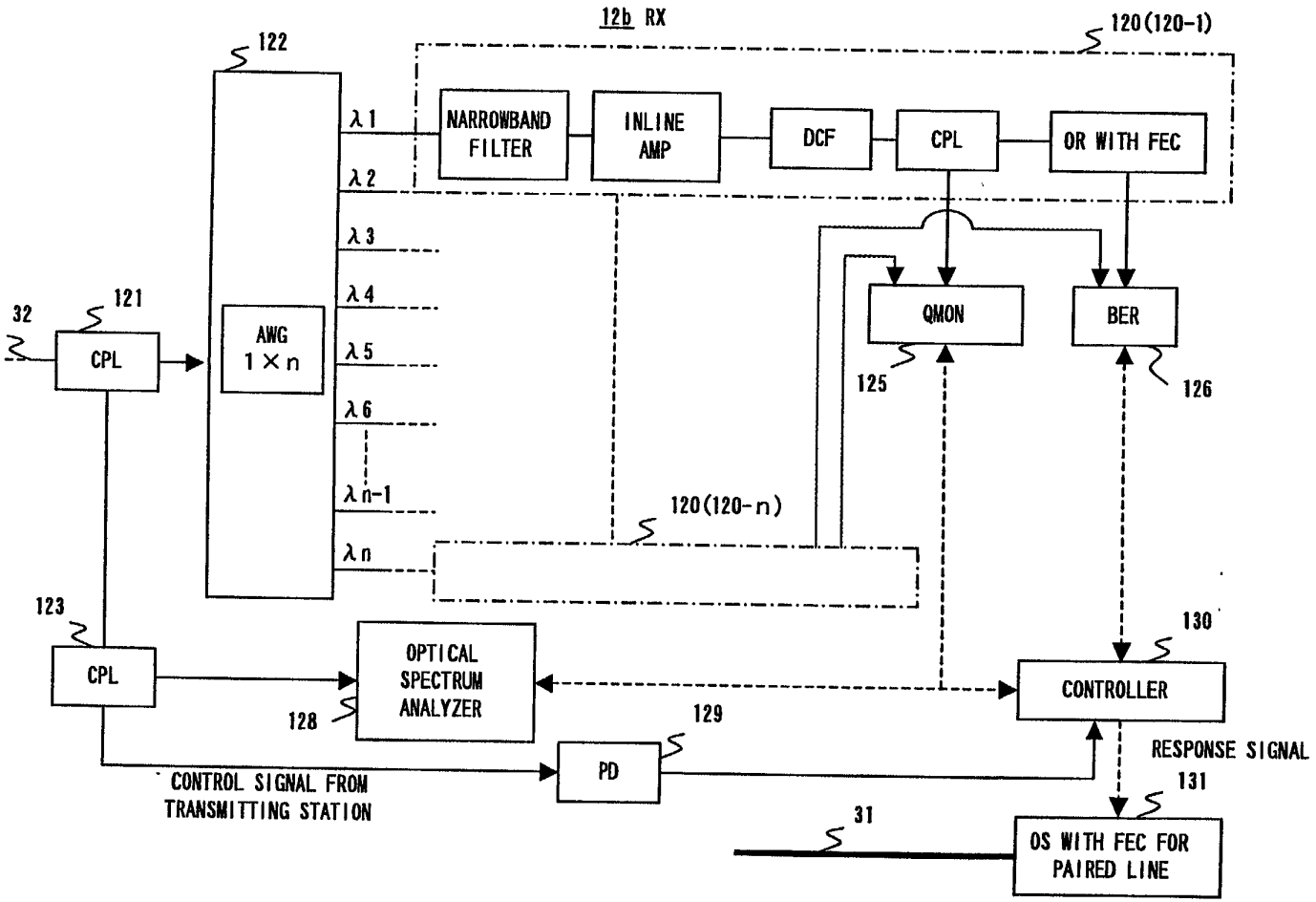

12b RX
120(120-1)
122
λ1
λ2
λ3
λ4
λ5
λ6
λn-1
λn
NARROWBAND FILTER
INLINE AMP
DCF
CPL
OR WITH FEC
32
121
CPL
AWG 1×n
QMON
BER
125
126
120(120-n)
123
CPL
OPTICAL SPECTRUM ANALYZER
128
129
PD
130
CONTROLLER
RESPONSE SIGNAL
131
CONTROL SIGNAL FROM TRANSMITTING STATION
31
OS WITH FEC FOR PAIRED LINE

FIG. 17

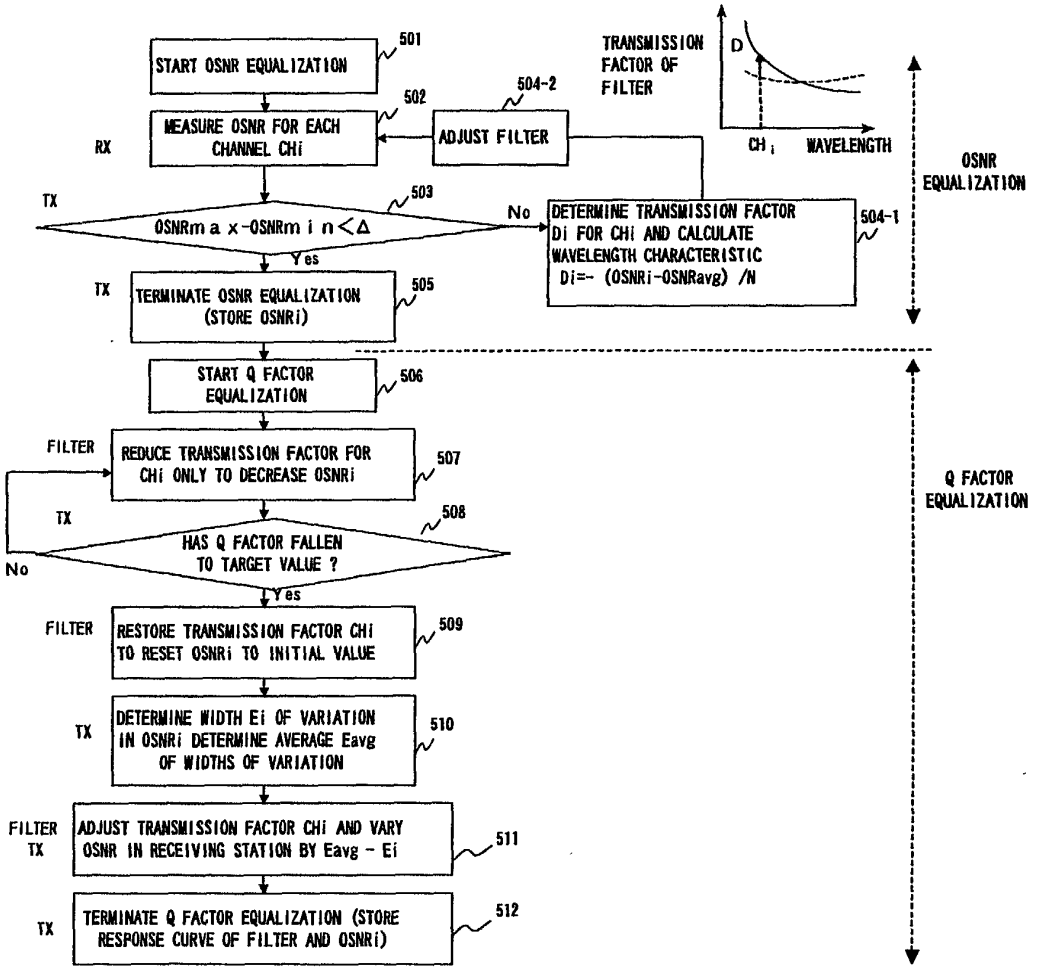

START OSNR EQUALIZATION
501
MEASURE OSNR FOR EACH CHANNEL CHi
502
RX
ADJUST FILTER
504-2
TRANSMISSION FACTOR OF FILTER
D
CH i
WAVELENGTH
OSNR EQUALIZATION
TX
OSNRmax-OSNRmin<Δ
503
No
DETERMINE TRANSMISSION FACTOR Di FOR CHi AND CALCULATE WAVELENGTH CHARACTERISTIC Di=- (OSNRi-OSNRavg) /N
504-1
Yes
TX
TERMINATE OSNR EQUALIZATION (STORE OSNRi)
505
START Q FACTOR EQUALIZATION
506
Q FACTOR EQUALIZATION
FILTER
REDUCE TRANSMISSION FACTOR FOR CHi ONLY TO DECREASE OSNRi
507
TX
HAS Q FACTOR FALLEN TO TARGET VALUE ?
508
No
Yes
FILTER
RESTORE TRANSMISSION FACTOR CHi TO RESET OSNRi TO INITIAL VALUE
509
TX
DETERMINE WIDTH Ei OF VARIATION IN OSNRi DETERMINE AVERAGE Eavg OF WIDTHS OF VARIATION
510
FILTER
TX
ADJUST TRANSMISSION FACTOR CHi AND VARY OSNR IN RECEIVING STATION BY Eavg - Ei
511
TX
TERMINATE Q FACTOR EQUALIZATION (STORE RESPONSE CURVE OF FILTER AND OSNRi)
512

FIG. 18

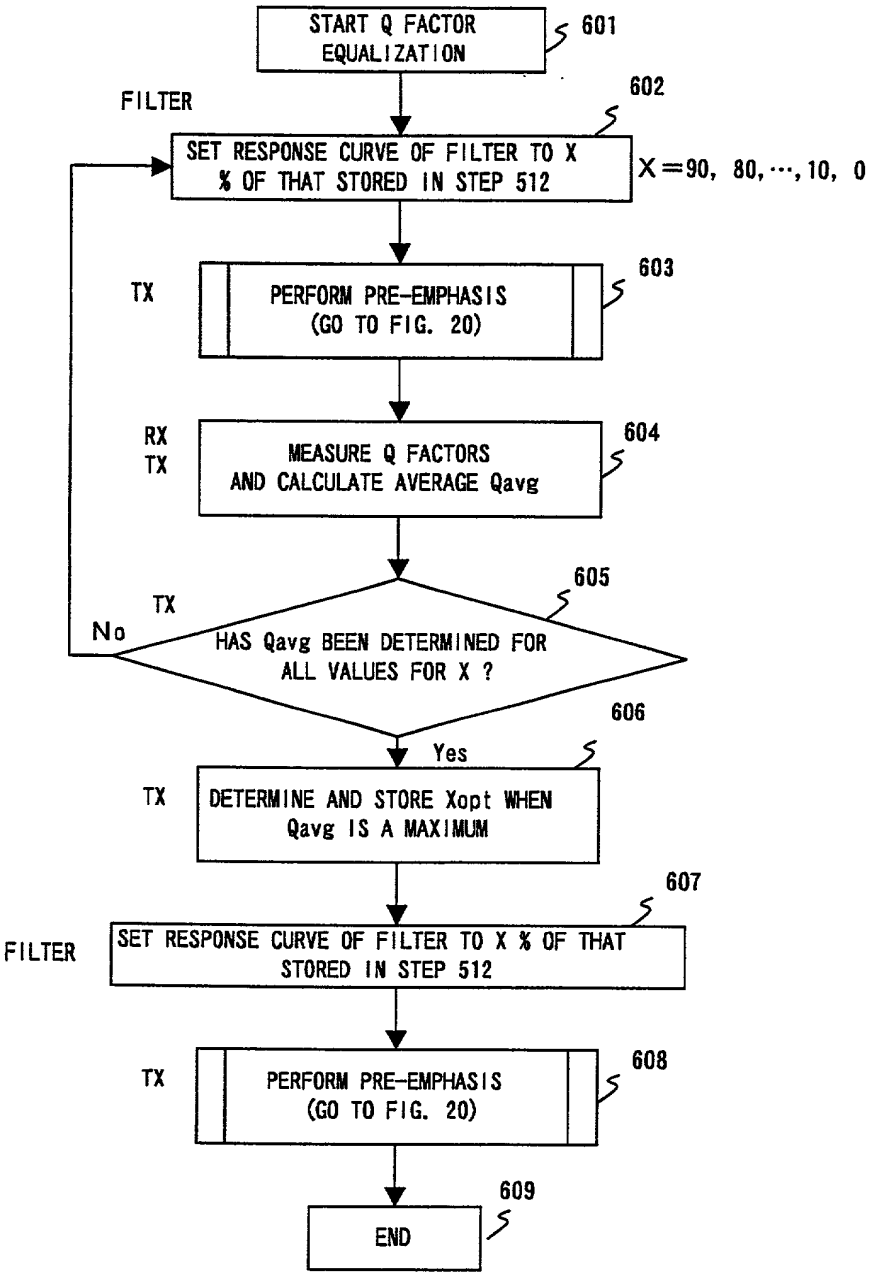
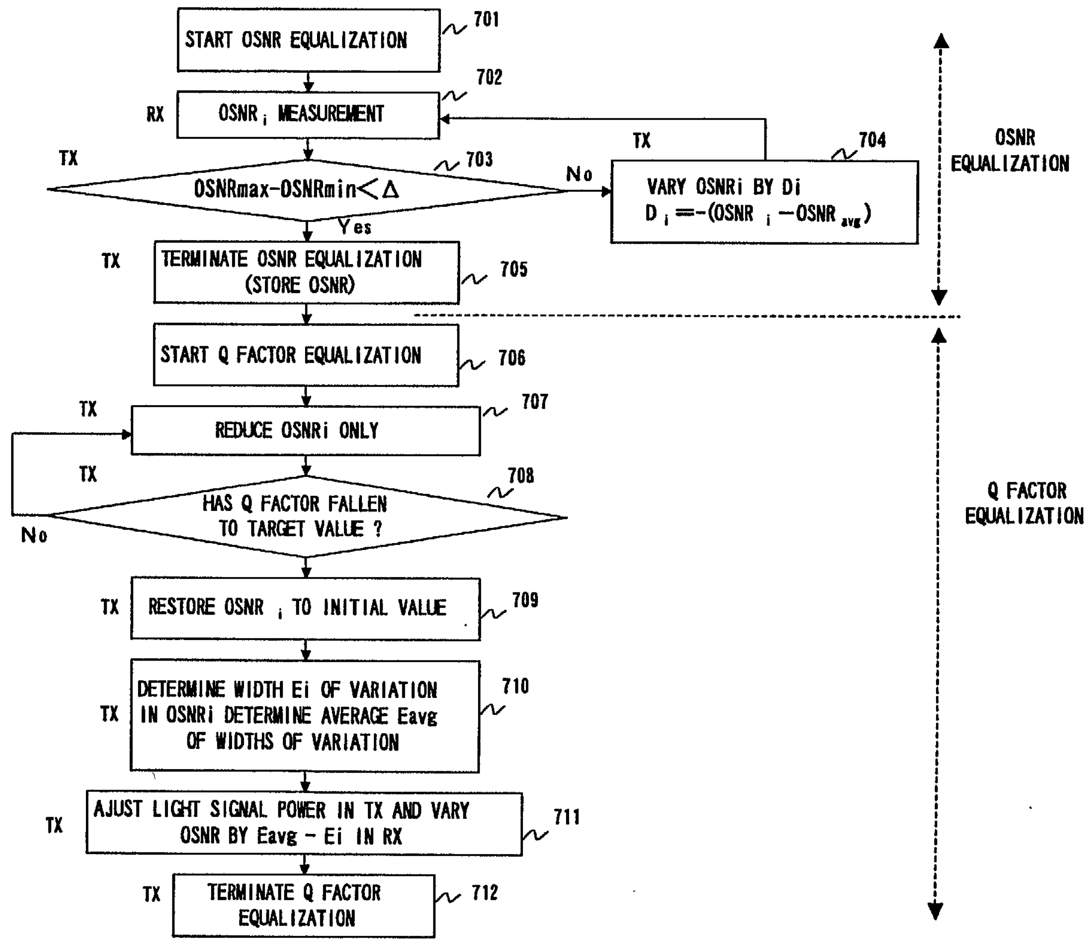

START Q FACTOR EQUALIZATION
601
FILTER
602
SET RESPONSE CURVE OF FILTER TO X % OF THAT STORED IN STEP 512
X=90, 80, ···, 10, 0
TX
PERFORM PRE-EMPHASIS (GO TO FIG. 20)
603
RX
TX
MEASURE Q FACTORS AND CALCULATE AVERAGE Qavg
604
TX
605
No
HAS Qavg BEEN DETERMINED FOR ALL VALUES FOR X ?
606
Yes
TX
DETERMINE AND STORE Xopt WHEN Qavg IS A MAXIMUM
607
FILTER
SET RESPONSE CURVE OF FILTER TO X % OF THAT STORED IN STEP 512
TX
PERFORM PRE-EMPHASIS (GO TO FIG. 20)
608
609
END

FIG. 19


START OSNR EQUALIZATION
701
RX
OSNR i MEASUREMENT
702
TX
OSNRmax-OSNRmin<Δ
703
No
TX
VARY OSNRi BY Di
D i =-(OSNR i -OSNR avg)
704
Yes
TX
TERMINATE OSNR EQUALIZATION
(STORE OSNR)
705
START Q FACTOR EQUALIZATION
706
TX
REDUCE OSNRi ONLY
707
TX
HAS Q FACTOR FALLEN
TO TARGET VALUE ?
708
No
TX
RESTORE OSNR i TO INITIAL VALUE
709
TX
DETERMINE WIDTH Ei OF VARIATION
IN OSNRi DETERMINE AVERAGE Eavg
OF WIDTHS OF VARIATION
710
TX
AJUST LIGHT SIGNAL POWER IN TX AND VARY
OSNR BY Eavg - Ei IN RX
711
TX
TERMINATE Q FACTOR
EQUALIZATION
712
OSNR
EQUALIZATION
Q FACTOR
EQUALIZATION

F I G. 2 0

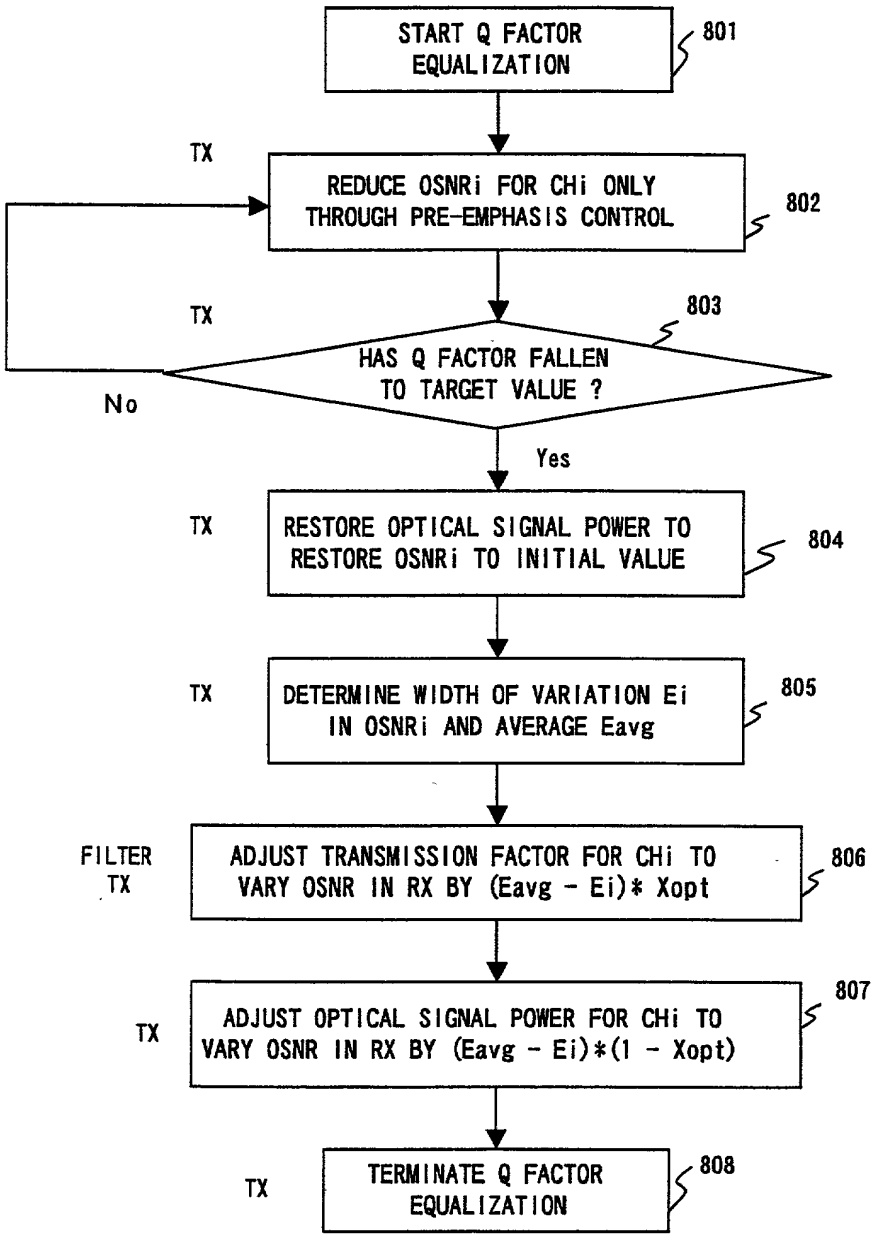
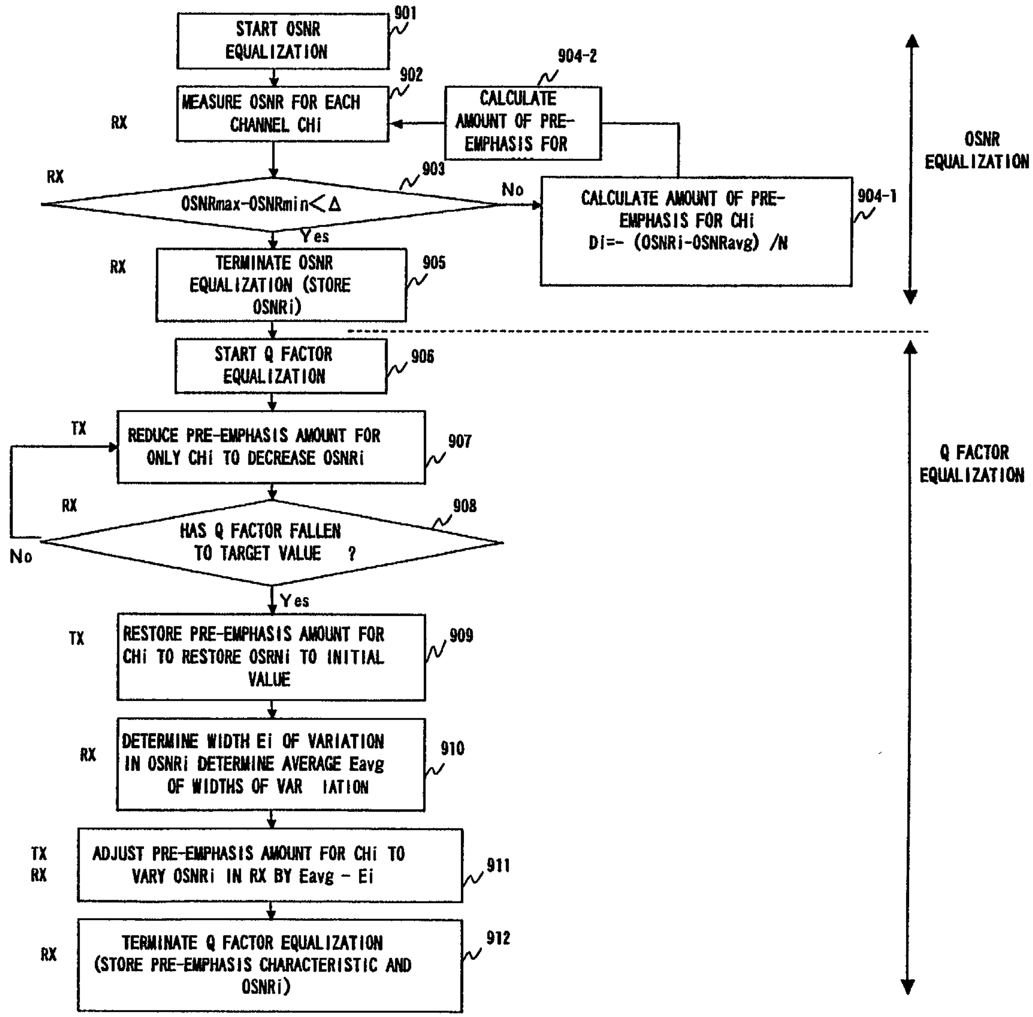

START Q FACTOR EQUALIZATION
801
TX
REDUCE OSNRi FOR CHi ONLY THROUGH PRE-EMPHASIS CONTROL
802
TX
803
HAS Q FACTOR FALLEN TO TARGET VALUE ?
No
Yes
TX
RESTORE OPTICAL SIGNAL POWER TO RESTORE OSNRi TO INITIAL VALUE
804
TX
DETERMINE WIDTH OF VARIATION Ei IN OSNRi AND AVERAGE Eavg
805
FILTER TX
ADJUST TRANSMISSION FACTOR FOR CHi TO VARY OSNR IN RX BY (Eavg - Ei)* Xopt
806
TX
ADJUST OPTICAL SIGNAL POWER FOR CHi TO VARY OSNR IN RX BY (Eavg - Ei)*(1 - Xopt)
807
TX
TERMINATE Q FACTOR EQUALIZATION
808

FIG. 21


START OSNR EQUALIZATION
901
MEASURE OSNR FOR EACH CHANNEL CHi
902
RX
CALCULATE AMOUNT OF PRE-EMPHASIS FOR
904-2
RX
OSNRmax-OSNRmin<Δ
903
No
Yes
CALCULATE AMOUNT OF PRE-EMPHASIS FOR CHi
Di=- (OSNRi-OSNRavg) /N
904-1
RX
TERMINATE OSNR EQUALIZATION (STORE OSNRi)
905
OSNR EQUALIZATION
START Q FACTOR EQUALIZATION
906
TX
REDUCE PRE-EMPHASIS AMOUNT FOR ONLY CHi TO DECREASE OSNRi
907
RX
HAS Q FACTOR FALLEN TO TARGET VALUE ?
908
No
Yes
TX
RESTORE PRE-EMPHASIS AMOUNT FOR CHi TO RESTORE OSRNi TO INITIAL VALUE
909
RX
DETERMINE WIDTH Ei OF VARIATION IN OSNRi DETERMINE AVERAGE Eavg OF WIDTHS OF VAR IATION
910
TX
RX
ADJUST PRE-EMPHASIS AMOUNT FOR CHi TO VARY OSNRi IN RX BY Eavg - Ei
911
RX
TERMINATE Q FACTOR EQUALIZATION (STORE PRE-EMPHASIS CHARACTERISTIC AND OSNRi)
912
Q FACTOR EQUALIZATION

F I G. 2 2

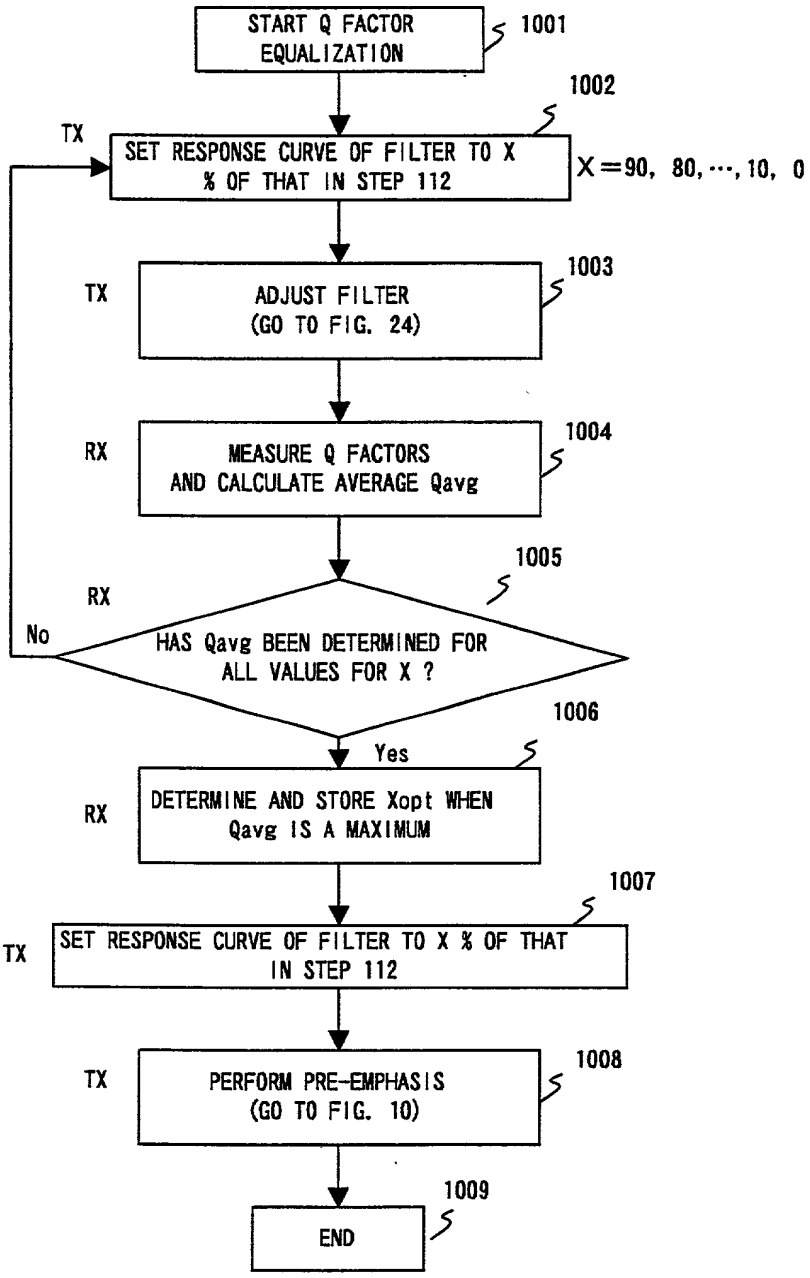
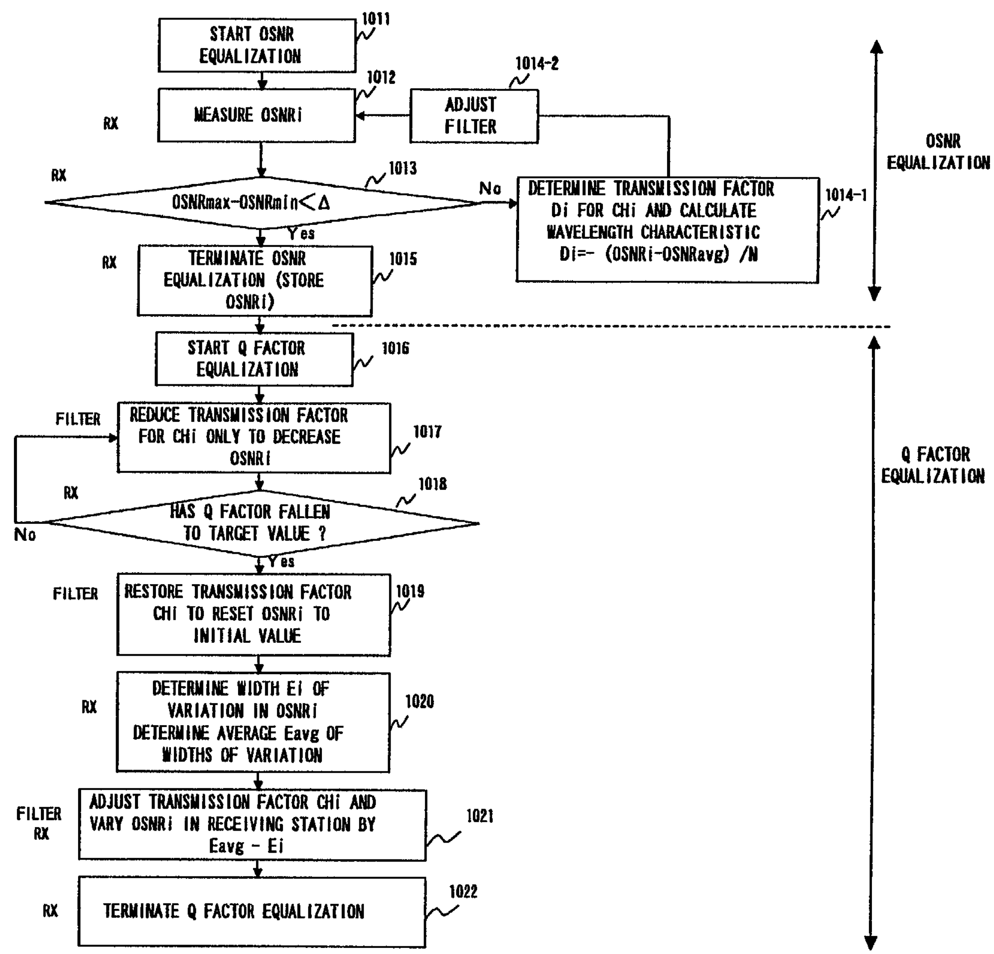

START Q FACTOR EQUALIZATION
1001
1002
TX
SET RESPONSE CURVE OF FILTER TO X % OF THAT IN STEP 112
X=90, 80, ···, 10, 0
TX
ADJUST FILTER (GO TO FIG. 24)
1003
RX
MEASURE Q FACTORS AND CALCULATE AVERAGE Qavg
1004
1005
RX
No
HAS Qavg BEEN DETERMINED FOR ALL VALUES FOR X ?
1006
Yes
RX
DETERMINE AND STORE Xopt WHEN Qavg IS A MAXIMUM
1007
TX
SET RESPONSE CURVE OF FILTER TO X % OF THAT IN STEP 112
TX
PERFORM PRE-EMPHASIS (GO TO FIG. 10)
1008
1009
END

FIG. 23


START OSNR EQUALIZATION
1011
RX
MEASURE OSNRi
1012
ADJUST FILTER
1014-2
RX
OSNRmax-OSNRmin<Δ
1013
No
Yes
DETERMINE TRANSMISSION FACTOR Di FOR CHi AND CALCULATE WAVELENGTH CHARACTERISTIC Di=- (OSNRi-OSNRavg) /N
1014-1
RX
TERMINATE OSNR EQUALIZATION (STORE OSNRi)
1015
OSNR EQUALIZATION
START Q FACTOR EQUALIZATION
1016
FILTER
REDUCE TRANSMISSION FACTOR FOR CHi ONLY TO DECREASE OSNRi
1017
RX
HAS Q FACTOR FALLEN TO TARGET VALUE ?
1018
No
Yes
FILTER
RESTORE TRANSMISSION FACTOR CHi TO RESET OSNRi TO INITIAL VALUE
1019
RX
DETERMINE WIDTH Ei OF VARIATION IN OSNRi DETERMINE AVERAGE Eavg OF WIDTHS OF VARIATION
1020
FILTER
RX
ADJUST TRANSMISSION FACTOR CHi AND VARY OSNRi IN RECEIVING STATION BY Eavg - Ei
1021
RX
TERMINATE Q FACTOR EQUALIZATION
1022
Q FACTOR EQUALIZATION

F I G. 2 4

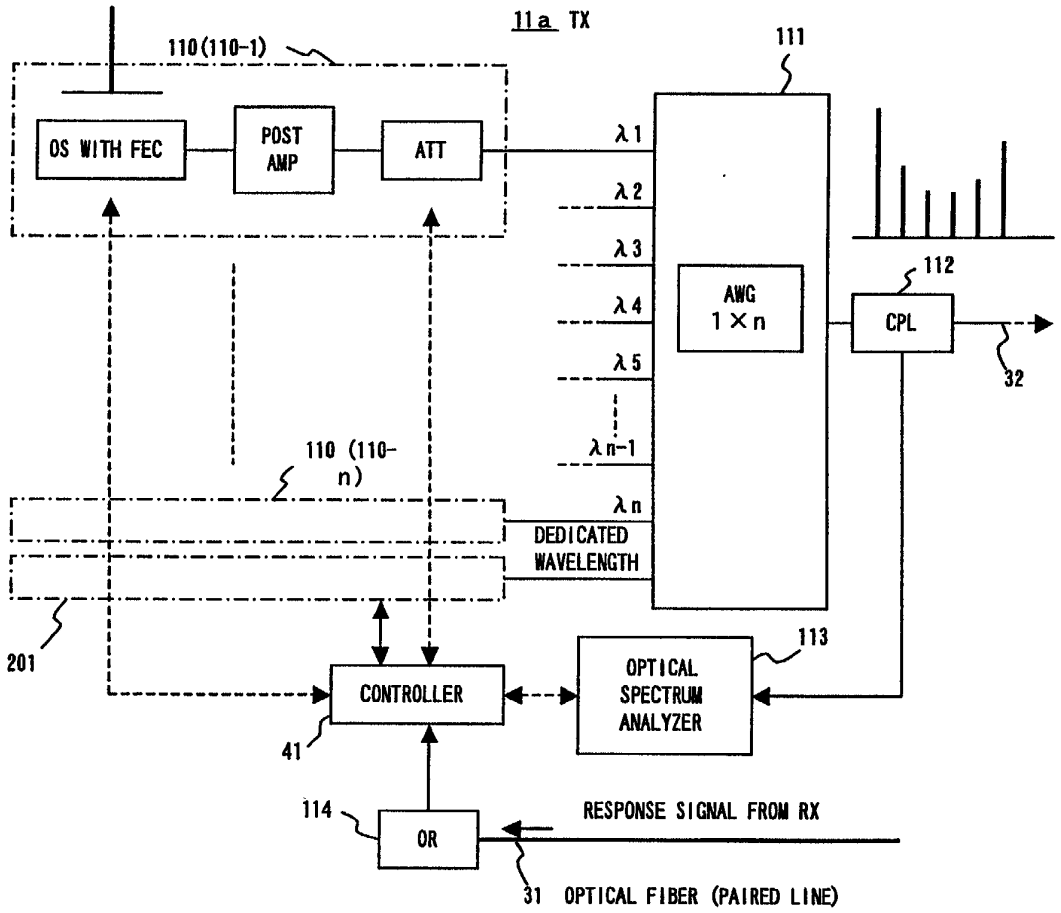
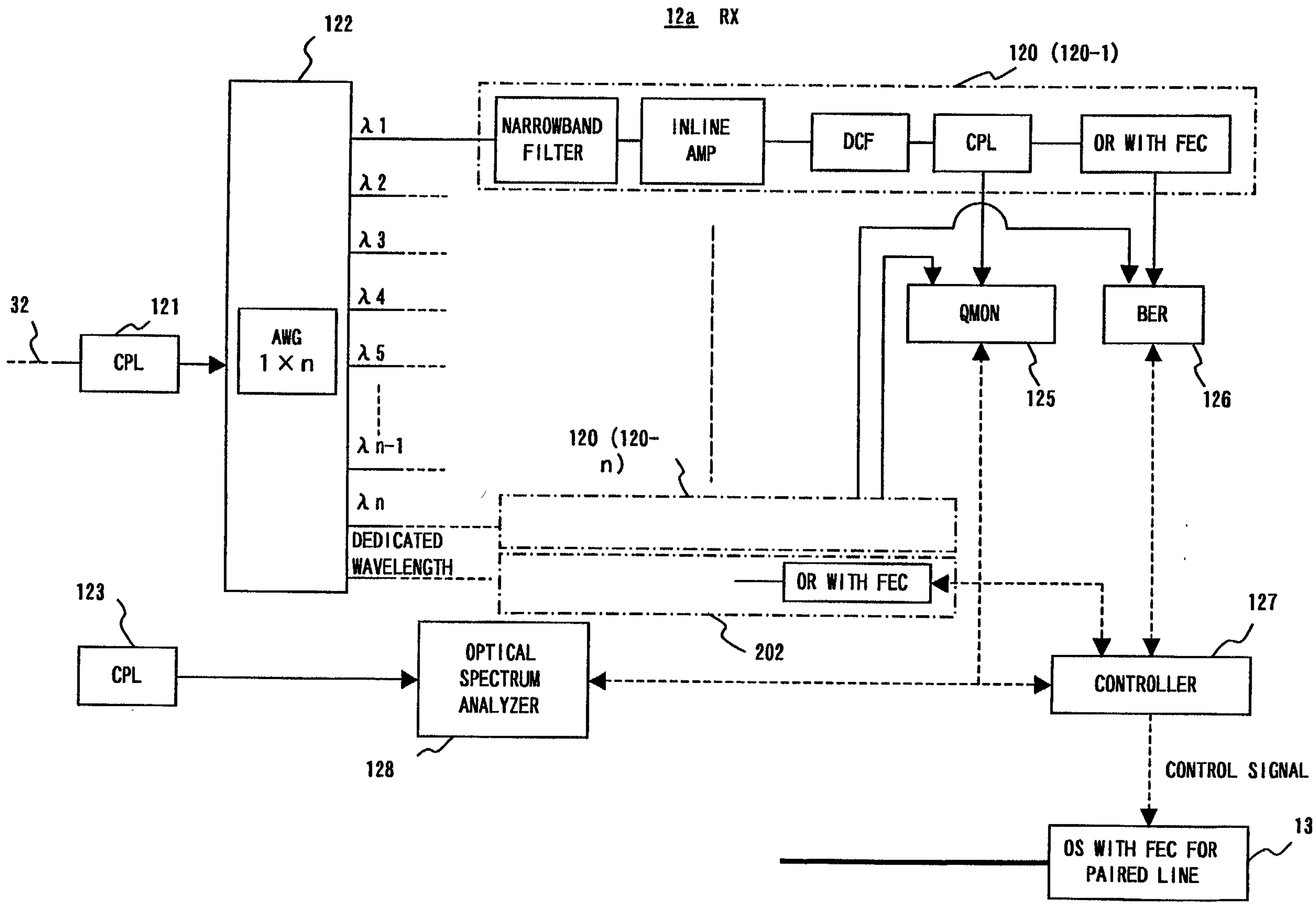

11a TX
110(110-1)
OS WITH FEC
POST AMP
ATT
λ1
λ2
λ3
λ4
λ5
λn-1
λn
111
AWG 1×n
112
CPL
32
110 (110-n)
DEDICATED WAVELENGTH
201
CONTROLLER
41
113
OPTICAL SPECTRUM ANALYZER
114
OR
RESPONSE SIGNAL FROM RX
31 OPTICAL FIBER (PAIRED LINE)

FIG. 25



12a RX
122
120 (120-1)
λ1
λ2
λ3
λ4
λ5
λn-1
λn
DEDICATED
WAVELENGTH
AWG
1×n
32
121
CPL
NARROWBAND
FILTER
INLINE
AMP
DCF
CPL
OR WITH FEC
QMON
BER
125
126
120 (120-
n)
OR WITH FEC
202
123
CPL
OPTICAL
SPECTRUM
ANALYZER
128
127
CONTROLLER
CONTROL SIGNAL
131
OS WITH FEC FOR
PAIRED LINE

F I G. 2 6